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A Multimarket Approach to Estimate a New Keynesian Phillips Curve*

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Abstract

We propose a new approach to estimate an "hybrib" New Keynesian Phillips Curve (NKPC) that includes demand pressures coming from disequilibrium relations in three different markets: (1) the monetary and financial, (2) the international, and (3) the labor market. In the application, our results show that all three markets contribute to the evolution of inflation. However, the effect of shocks on equilibrium in the labour market and short run movements in cyclical output are relatively more important than other shocks. Based on econometric tests, this specification is proved to be superior to the traditional NKPC that includes a single variable to account for demand pressures.

Keywords: New Keynesian Phillips Curve, Cointegration, Monetary Policy.

JEL Classification: E3, C3.

* We appreciate the comments by Klaus Schmidt-Hebbel and participants at the 2007 Encuentro de la Sociedad de Economía de Chile. The usual qualifier applies.

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1. Introduction

In this paper we propose a new approach to estimate the New Keynesian Phillips Curve (NKPC). We modify the traditional aggregated NKPC to include excess demand pressures arising from three different markets. In the empirical application, we use data for the Chilean economy. Our results indicate that inflation is explained by pressures coming from all markets, but that shocks in the labor market, and short run deviations of output, are relatively more important than other shocks to explain inflation. The proposed specification turns out to be superior to the traditional NKPC specification that includes excess demand pressures from a single market.

Based on the New Keynesian theoretical framework, a menu of models for the New Keynesian Phillips Curve (NKPC henceforth), that consider forward looking and optimisation behaviour by firms and households, in the context of price rigidities, as well as hybrid models which include backward looking behaviour, have been estimated and evaluated with data for both industrial countries like the US and the Euro Zone and Middle Income Countries. Gali and Gertler (1999), Gali et al. (2001) and Fanelli (2006) found evidence which renders support to the NKPC and the relevance of forward looking behaviour. In contrast, Rudd and Whelan (2005) have cast doubts on Gali's empirical results. Indeed, they found evidence that the NKPC is consistent with a backward looking Phillips curve based in the hybrid version approach. For the case of Chile, Cespedes et al. (2005) have estimated a NKPC and found evidence that support a backward looking behaviour. Particularly important is the evidence from a sub sample under the presence of backward indexation of prices and wages.

One of the limitations of the empirical model in the literature concerns the narrow approach used to treat the excess demand variable in the NKPC. Results in Hendry (2001) suggest that there is not a "single-cause" explanation for the UK inflation, because this variable responds to excess of demand

from all the sectors in the economy. In spite of this result, empirical estimation of the NKPC in the previous literature only consider demand pressures coming from at most two (internal and external) markets; see Gali and Gertler (1999), Gali et al. (2001) and Fanelli (2006) among others.

This research proposes a new approach to estimate an "hybrid" New Keynesian Phillips Curve that separately consider a large number of different variables that measure demand pressures in different markets. This methodology also considers a NKPC that includes long and short run inflation dynamics. We do this following a two-step procedure. In the first step, potential cointegration relationships are separately analyzed in three different vector equilibrium models where inflation is explained by (1) the effect of monetary and financial variables, (2) information on international markets, and (3) production costs. In doing this, we follow the principle of 'specific to general' in the choice of variables, albeit 'general to specific' in the choice of the statistical model; see Juselius and MacDonald (2004), Juselius (1992); and Garratt et al. (2000). The approach is justified as VAR models are very powerful for a detailed analysis of small systems, but almost unmanageable in large systems. Moreover, the cointegration property is invariant to increases in the information set. Thus, any cointegration result found for a given set of variables can also be found in an extended analysis. Once the cointegration relationships are identified in the three markets, in a second step, we incorporate this information to obtain the structural parameters of the NKPC. In this model, inflation is allowed to be affected by shocks in the cointegration relations in the three markets as well as the short run dynamics induced by a group of fundamental variables. Based on econometric tests, this specification is proved to be superior to other NKPC curves in the literature such as the traditional NKPC that includes a single variable to account for demand pressures and the model proposed by Fanelli (2006). The empirical application of this procedure is based on data from the Chilean economy.

The remainder of the paper is organized as follows. The next section highlights further the connection between our work and the previous literature. Section 3 considers the main problems in extending the traditional NKPC to a model that includes demand pressures from different markets affecting long run and short run inflation dynamics. The next section analyses separately the presence of cointegration relationships in the money, international and labour markets. These cointegration relationships are used in Section 5 to specify and estimate a NKPC that reacts to disequilibria in the different markets and compare it with other more conventional NKPC in the literature. Section 6 simulates the past evolution of the Chilean inflation under alternative scenarios. This analysis is proved to be useful to appraise the importance of past events in affecting the evolution of Chilean inflation. Some concluding remarks follow in Section 7.

2. A Quick Glimpse to the NKPC Theoretical Framework.

One of the empirical observations on macroeconomics has been the wrong predictions on inflation-unemployment (output) trade-off which has been derived from a traditional theoretical Phillips Curve, as well as lacking of strong and microeconomic underpinning consistent with optimising agents. The traditional Phillips equation which relates actual inflation to past values of inflation and a real variable which measure deviations of output from trend or alternatively deviation of unemployment from its natural rate did not perform well. The lagged values of inflation suggest that agents form their expectations of inflation on a backward looking fashion and hence past inflation can be introduced into the structure of wages and prices producing inertia. The second term in the traditional Phillips Curve measures excess demand pressures.

The New Keynesian Phillips Curve (NKPC) incorporates both rational expectations forward looking behaviour in price and wage setting and microeconomic foundations developed in New

Keynesian theoretical framework. Forward looking models with price rigidities has been introduced in the form of staggered contracts following the model of Taylor (1980, Calvo (1983), Rotemberg (1982) and Fuhrer and Moore (1995). These models assume that monopolistic firms set wages in nominal terms at discrete and different periods of time producing an overlapping structure of contracts. In this way, persistence in the aggregate price level is induced. For instance, in the Calvo model, firms follow time consistent price adjustment rules with random adjustments and with a fraction of firms adjusting their prices. An alternative model to the standard sticky-price model is the sticky-information model. Mankiw and Reis (2001) argued that the sticky-information model is closer to the overlapping contract model developed by Fischer (1977). Price setting is based partially on old decisions as well as old information. Specifically, a fraction of firms obtains new information about the economy and compute a path of optimal prices while other firms set prices on old and outdated information.

These theoretical models had provided a framework to specify a forward looking Phillips Curve where actual inflation will depend on the expected inflation conditional on all current information, an output gap which will be inversely related to any price rigidity or inertia. (Roberts 1995). Gali et al (2001) related the excess demand-output gap variable with a real marginal cost variable which is captured empirically by real unit labour costs. This estimation has provided a better fit to the data. The model has also an alternative version which includes a backward looking lagged inflation parameter that captures a fraction of firms with this behaviour. This generally is called a Hybrid Phillips Curve, which has also provided a good first approximation of the inflation dynamics in the US and the Euro Zone. It is important to stress the issue of the importance of the forward looking inflation in the dynamics and the price rigidity which is captured by a single driving variable, such as the output gap, unemployment or marginal cost. The model can be extended to a small open economy version, where the exchange rate can produce a pass through

effect on domestic inflation through import prices for intermediate goods. (See Batini et al. 2005).

The NKPC model built on a standard sticky-price model should be a better representation of the inflation dynamics. However, the NKPC has an important shortcoming by looking at the inflation dynamics in a very narrow sense. Indeed, inflation may not only respond to excess demand factors in a single market but also to disequilibrium on the labour, goods, foreign exchange markets all together. (Hendry 2001) Hence, a multimarket approach can be deemed as an useful device in order to improve our understanding on inflations and its dynamics. This approach is discussed in the next section with reference to the hybrid model.

3. Inflation and Multiple Market Pressures.

The "hybrib" New Keynesian Phillips Curve (NKPC) expresses the inflation rate as a function of the expected rate of inflation, lagged inflation and a set of control variables. Galí et al. (2001) propose the following functional form:

$$\pi_t = \theta E_t \pi_{t+1} + \delta \pi_{t-1} + \lambda' x_t + a_t \quad (2.1)$$

where π_t is the inflation rate at time t ; $E_t \pi_{t+1}$ is the expected value at time t of the inflation rate at time $t+1$; x_t is a $(n \times 1)$ vector of exogenous explanatory variables; a_t is an error term; and θ , δ and λ are structural parameters, with λ a $(n \times 1)$ vector.

In most papers, x_t is a single variable that indicates demand pressure such as the output gap or the unemployment rate. Only some small-open economy versions of the NKPC include a second variable in x_t to account for external demand pressure; see for example Peturson and Batini et al. (2005).

Here, and this is a main contribution of this paper, we separately consider a large number of different variables that indicate demand pressures in different markets. Let's split x_t in two groups of variables $x_t' = (x_{l,t}', x_{c,t}')$ where $x_{l,t}$ is a $n_1 \times 1$ vector of nonstationary variables (or combination of variables) that work in an equilibrium relationship with π_t ; and $x_{c,t}$ is a $n_2 \times 1$ vector of stationary variables that potentially can affect the short run inflation dynamics, $n_1 + n_2 = n$.

Using the last definition, equation (2.1) can be expressed as:

$$\pi_t = \theta E_t \pi_{t+1} + \delta \pi_{t-1} + \lambda_1' x_{l,t} + \lambda_2' x_{c,t} + a_t. \quad (2.2)$$

where λ_1 and λ_2 are vector of parameters with dimension $(n_1 \times 1)$ and $(n_2 \times 1)$ respectively.

The 1-step ahead inflation forecast implied by this equation is given by

$$E_t \Delta \pi_{t+1} = \left(\frac{1 - \theta - \delta}{\theta} \right) \sum_{i=1}^{n_1} (\pi_t - \beta^i x_{l,t}^i) + \left(\frac{\delta}{\theta} \right) \Delta \pi_t - \left(\frac{\lambda_2'}{\theta} \right) x_{c,t} \quad (2.3)$$

where $\beta^i = \frac{\lambda_1^i}{(1 - \theta - \delta)}$, Δ is a difference operator, and $x_{l,t}^i$ and λ_1^i are respectively the i th elements in vectors $x_{l,t}$ and λ_1 .

Notice that the last specification is very similar to the one proposed by Case 2 in Fanelli's specification (2006). However, an important difference with this approach is that in our structural Phillips curve we jointly consider the set of variables affecting the short and long run inflation dynamics instead of studying them as two alternative cases. A second difference lies in the fact that in our model each of the $x_{l,t}^i$ variables corresponds to demand pressures coming from equilibrium

relationships in different markets. This last issue will be more specifically outlined in the next section.

It is straightforward to obtain the parameters in (2.3) from a reduced form specification similar to this

$$\Delta\pi_t = c + \sum_{i=1}^{n_1} \alpha_i (\pi_{t-1} - \gamma^i x_{t,t-1}^i) + \phi \Delta\pi_{t-1} + \rho' x_{c,t-1} + u_t. \quad (2.4)$$

where ρ is a $n_2 \times 1$ vector of parameters and c , α_i , γ^i , ϕ are scalars.

Then, structural parameters can be obtained by matching expressions (2.3) and (2.4). It turns out that

$$\alpha_i = \left(\frac{1 - \theta - \delta}{\theta} \right) \quad (2.5)$$

$$\phi = \frac{\delta}{\theta} \quad (2.6)$$

$$\rho' = -\frac{\lambda_2'}{\theta} \quad (2.7)$$

In the following section we specify and estimate a reduced form model similar to (2.4) that includes information about cointegration relationships in three markets: labor, money and external markets. Then, restrictions (2.5), (2.6) and (2.7) can be imposed on the reduced form equation in order to obtain the parameters of an hybrid NKPC that contains information about demand pressures in several markets.

4. Cointegration Analysis in Three Markets

We follow a two-step procedure in order to specify and estimate a Phillips curve for the Chilean economy. The first step identifies long run relations in three different markets. Then, in the second step, we estimate an inflation equation including the information about all the equilibrium relationships found in the three markets considered. This

section focuses on the first step where potential cointegration relationships are separately analyzed in three different vector equilibrium correction (VecC) models where Chilean inflation is explained by (1) the effect of monetary and financial variables, (2) information on international markets, and (3) production cost. The first vector models long run equilibrium in the asset markets, where the interplay between demand and supply for financial assets can affect price inflation. The second relation depicts the exchange rate market balance and the effects of exchange rates and interests rates on domestic inflation. Finally, the third model represents labor market equilibrium and the effect of wages and productivity on cost inflation.

We consider the following quarterly series: a measure of average labour productivity in Chile obtained as the ratio of the real GDP over the number of workers, (Pr_t) ; the Chilean real wages, (w_t) ; the Chilean Consumer Price Index in first differences, (π_t) ; the Chilean unemployment rate, (u_t) ; a short run nominal interest rate series for Chile, (i_t) ; the nominal exchange rate expressed as the number of Chilean pesos for one dollar, (e_t) ; the U.S nominal fed rates, (i_t^*) ; the American Consumer Price Index in first differences, (π_t^*) ; the real GDP in Chile, (y_t) ; and first differences of the Chilean M2 monetary aggregate, (Δm_t) .¹ We took natural logarithm of the series with the exception of u_t , i_t and i_t^* . Our analysis covers the period 1987:Q1–2006:Q2.

Now, we investigate the possible cointegration relationships found for the different groups of these variables. The first group, relates to the money and financial market and includes: i_t , π_t , y_t and Δm_t . The variables in the second group are: i_t^* , π_t^* , i_t , π_t , and e_t . These variables account for the influence of the foreign market in the Chilean inflation. We

¹ A more detailed description of the different series and the sources where these series have been obtained is confined to the appendix.

consider a last set of variables: Pr_t , w_t , u_t and π_t to measure inflationary pressures that comes from the labour market.

For each of the groups above, we depart from the estimation of the following vector equilibrium correction model

$$\Delta Y_t = \mu + \Pi \begin{pmatrix} Y_{i,t-1} \\ 1 \\ t \end{pmatrix} + \Phi \Delta Y_{t-1} + \varepsilon_t \quad (3.1)$$

where Y_t is the vector of variables included in a given group; Π is matrix of parameters whose rank is restricted by the number of cointegration relationships; t is a deterministic trend scalar; μ is a vector of intercept parameters; Φ is a matrix of parameters; and ε_t is a vector of serially uncorrelated errors.

Notice that we allow for two deterministic intercepts in expression (3.1), one is included in the cointegration equation and the other only affects the short run dynamics. However, the trend component is only included in the cointegration equation since imposing a quadratic deterministic trend in Y_t is generally an implausible assumption. The presence of deterministic components in the initial specification (3.1) can be tested in subsequent steps following the principle 'from general to specific' in the specification of the model, see Juselius (2007).

A) Monetary and Financial Market: the trace test indicates that the null of no cointegration can be rejected at the 1% but the hypothesis of at least one cointegration relationship has a p-value of 0.16. After imposing the normality restriction, the cointegration equation adopts the following form (with standard values between brackets):

$$CM : i_t = \underset{(0.03)}{0.4} \pi_t + \underset{(0.004)}{0.02} y_t - \underset{(0.02)}{0.08} \Delta m_t + \underset{(0.00005)}{0.0004} t \quad (3.2)$$

We test for the exclusion of different variables in this equation using a likelihood ratio test, see Johansen (1995). However, the null hypothesis was always rejected at the conventional levels.

According to the sign of the estimated parameters, equation (3.2) can be interpreted as a Taylor rule as the interest rate increases with inflation and output but is negatively affected by money.

B) External Market: Economic theory typically expects, that in order to fulfill the purchasing power parity, the national rate of inflation should be in equilibrium with the U.S inflation and the exchange rate. However, the purchasing power parity cointegration relationship could not be accepted from our empirical analysis. Consistently with Juselius (1995), we find that a cointegration relationship holds once we introduce interest rate variables to equilibrate the goods and capital markets.

Thus, the trace test indicates the presence of a single cointegration relationship in this market that takes the form:

$$CX : i_t^* - \pi_t^* = 0.5i_t - 0.35\pi_t - 0.005e_t \quad (3.3)$$

The two overidentifying restrictions imposed in this equation are: (1) there is no deterministic trend; and (2) the parameter associated to the US inflation takes value -1. These two restrictions cannot be rejected at the conventional levels using a standard likelihood ratio test.

Equation (3.3) can be interpreted as an equilibrium relationship between the Chilean and the US interest rates in real terms.

C) Labour Market: the trace test indicates that it is possible to reject the null hypothesis of no cointegration and at least one cointegration relationship at the 1% level. However, it is not possible to reject the null of at least two cointegration relationships at the conventional levels.

After imposing overidentifying restrictions we obtain the following cointegration equations:

$$CL1: w_t = Pr_t - 0.001t \quad (3.4)$$

$$CL2: \pi_t = -0.1Pr_t \quad (3.5)$$

The first cointegration relation (3.4) can be interpreted as a (real) wage function where wages and productivity share a common unit root. The second cointegration relation (3.5) indicates a long run relationship between inflation and productivity. Since productivity is inversely related to unit costs, this could be interpreted as a marginal cost pricing equation. It can be noted that these partial analysis do not give support to the existence of a long run trade off between unemployment and inflation in the labor market.

Figure 1 exhibits the four cointegration equations found in this analysis. A visual inspection of the figures reveals that they are clearly stationary.

[INSERT FIGURE 1]

5. Estimation of a Fully Informative Phillips Curve

The information about the equilibrium relationships in different markets can be easily incorporated into the reduced form Phillips curve presented in (2.4). To see this, notice that

(3.2) , (3.3) and (3.5) indicate a long run equilibrium relation between inflation and a combination of variables. Therefore, they can be written respectively as $\pi_t - \beta^m x_{l,t}^m$, $\pi_t - \beta^x x_{l,t}^x$ and $\pi_t - \beta^l x_{l,t}^l$ where the elements $x_{l,t}^m$, $x_{l,t}^x$ and $x_{l,t}^l$ are combinations of variables that condition the long run Chilean inflation in the three markets of interest. Additionally, we include the vector of variables affecting the short run inflation dynamics, i.e $x_{c,t}$ in (2.4), that contains lagged values of Δy_t and of the rest of variables in the analysis after being transformed to be stationary. .

We obtain the following estimation after eliminating non significant variables following a step-wise procedure (with standard deviations between brackets):

$$\begin{aligned} \Delta \pi_t = & -0.003_{(0.001)} - 0.37_{(0.24)} (\pi_{t-1} - \mathbf{x}_{l,t-1}^m) - 0.20_{(0.13)} (\pi_{t-1} - \mathbf{x}_{l,t-1}^x) - 0.20_{(0.10)} (\pi_{t-1} - \mathbf{x}_{l,t-1}^l) \\ & + 0.15_{(0.03)} \Delta \mathbf{y}_{t-2} - 0.21_{(0.11)} \Delta \pi_{t-1}, \end{aligned} \quad (4.1)$$

with an adjusted $R^2 = 0.51$.

In this final estimation we do not consider the cointegration relationship given by expression (3.5) as its effect is clearly non significant. Also, in the initial specification, we included as explanatory variables the stationary transformation of all the variables in the analysis but only the first difference of lagged inflation and the lag two of output turn out to be significant.

The sign of the estimated parameters in this estimation is consistent with economic theory. In the asset, exchange rate, and labor markets, when inflation is greater than what is compatible with equilibrium, the disequilibrium position will generate a stabilizing downward movement in inflation rates. The most important factor to determine Chilean inflation in the long run is labor productivity. Excess of demand in the monetary, and foreign markets are not so important but show the expected sign. Additionally, inflation is significantly affected

in the short run by increases in production, as expected, with two quarters lag.

Note that restrictions from (2.5) should be imposed in our estimation to obtain the structural equation (2.3). We test these restrictions with a standard F statistic. The test has a p-value of 0.84 and therefore it is not possible to reject these restrictions at the conventional levels.

It is also of interest to test two alternative Phillips curves found in the literature. For example, a traditional NKPC that only allows short run dynamics amounts to assuming that the three parameters of adjustment to the equilibrium in the three markets are equal to zero. Using a F test we reject this restriction at the 1% level. A second alternative model is Case 2 in Fanelli's nomenclature (2006). He considers the possibility of common unit roots in the variables included in the Phillips curve. However, his structural model when variables are cointegrated only allows for the possibility of short run adjustment. We test this by restricting Δy_{t-2} to have no effect on $\Delta \pi_t$. However, we reject this restriction using standard procedures at the 1% level.

Estimation in (4.1) can be also used to obtain structural parameters. One way to do that is by using an indirect procedure, such as the delta method, to match the parameters in the reduced form and the structural model using (2.5), (2.6) and (2.7). We do it directly imposing these restrictions in the estimation of (4.1). Table 1 shows the results of the estimation of model (2.3). For the purpose of comparison, we also include the estimation results of a model that does not include short run dynamics.

Table 1. Structural Estimation.

	Model (2.3)	Model without short run dynamic
Constant	-0.003 (0.001)	-0.004 (0.001)
$\hat{\theta}$	1.81 (0.27)	1.97 (0.37)
$\hat{\delta}$	-0.40 (0.23)	-0.30 (0.27)
$\hat{\lambda}_2$	-0.27 (0.06)	<hr/>
Adj-R ²	0.51	0.34
Akaike	-6.38	-6.08

Standard errors are between brackets.

The adjustment of the model that includes both short and long run adjustment clearly outperforms a model with only long run adjustment. Moreover, imposing this restriction affects the value of the estimated structural parameters.

Some of the estimated results are interesting and contradict some of the findings found for Chile by other authors. The coefficient $\hat{\theta}$, which captures forward looking inflation in the equation, is statistically significant. This result provides evidence of the role of expectations on the inflation process. Similar results are found for Gali and Getler (2001) for data on the US and Euro Zone.

In contrast $\hat{\delta}$, which accounts for the lagged inflation, is not significant and with wrong sign. Cespedes et al.(2005), however, found that backward looking inflation was significant. This later evidence is also consistent with Rudd and Whelan (2005) for the US inflation. Equally, Agenor and Bayraktar (2003) found significant estimates for lagged and forward inflation for Chile.

Therefore, we run a number of different experiments, not explicitly reported, to check the robustness of our results. First, we estimate structural parameters using only information for the period 1997Q1-2000:Q4, but main results about the estimation of structural parameters remain unaltered. Concretely, $\hat{\theta}$ is significant and takes value 1.93 while $\hat{\delta}$ takes a nonsignificant value. In a second experiment, we estimate a traditional "hybrid" NKP curve including only parameters for short run adjustment in the specification. Results also highlight the importance of inflation expectations in the NKP, $\hat{\theta}$ is significant and takes value 2.07. In a third experiment, we estimate the NKP phillips curve including only demand pressures coming from the cointegration relationships in the labour market. We consider, this experiment is relevant given that Cespedes et al.(2005) uses an estimation of marginal cost as their measure of output gap. In this case, the estimation of $\hat{\theta}$ is again significant and takes value 2.31. In a final experiment, we estimate expression (2.2) by GMM finding that results fluctuate a lot depending on the instruments selected in our estimation. An important advantage of the estimation procedure used in this paper compared to GMM is that our methodology does not use any instrument in the estimation process.

6. Analysis of Alternative Scenarios.

Given the NKPC estimated in the previous section, an interesting exercise is to solve the model in order to simulate the inflation path under alternative scenarios of the variables affecting the Chilean economy during the period of analysis. Concretely, we want to adress the importance of the effect of the economic crisis at the end of the nineties, the so called "Asian Crisis", and the important reduction of the American interest rates during the period 2001-2004.

Two equations are considered in the simulation. The first one is the NKPC estimated in the previous section. In this equation, the dependent variable is the growth of prices which is allowed to be affected by shocks in the different markets. We also take into account the fact that monetary policy is not exogenous but can react to changes in the inflation rate. Thus, our second equation is a policy rule. The Central Bank of Chile assumes that the short run interest rates react to its lagged value, the expected inflation and the lagged cyclical output; see Central Bank (2003). A subsequent empirical analysis by Parrado (2004) estimates interest rates as a function dependent on its lagged values and expected inflation. Our approach is similar in spirit to Parrado's specification. Concretely, we estimate a simple Taylor rule very similar to the one proposed by Parrado where interest rate is a function of its previous value and the current annual rate of inflation obtaining the following specification

$$i_t = 0.93 * i_{t-1} + 0.0002 * \left(\left(\frac{P_t - P_{t-4}}{P_{t-4}} \right) * 100 \right) \quad (5.1)$$

where P_t is the Chilean Consumer Price Index at time t .

Also, in an experiment not reported here, we consider the cointegration relationship given by equation (3.2) to determine endogenously nominal interest rates in Chile. However, results are very similar to the ones presented in this section.

Given that our estimation of equation (2.3) includes information about long run equilibria in different markets, it is posible to simulate the impact of different types of shocks in the evolution of inflation and interest rate in a simple system of two equations. We are aware that a potential limitation of this simple model compared with a big structural model is that here we only consider two endogenous variables and do not take into account the interrelation of all the variables that can potentially affect the Chilean economy. However, on the other hand, big models are more complex to estimate and comprises the estimation of more parameters that can make the simulation more imprecise. Another important limitation of this

procedure is related to the Lucas critique. Indeed, it is possible to argue that if different shocks would have hit the Chilean economy, the monetary rule would have also been different. For this reason, this exercise only tries to answer the question: what would have happened if a different shock had hit the Chilean economy leaving everything else constant.

The question to answer in the first simulation is: what would have happened if the Chilean GDP would not be affected by the Asian crisis at the end of the nineties. This crisis was triggered by the devaluation of the Thai baht in 1997 and had a profound impact on the growth trajectory of the Chilean economy. After this economy had been growing approximately at a 7% annual rate during a 10 years period, its growth rate fell to 3.2% in 1998, and -0.8% in 1999 as a consequence of the effects of the Asian crisis. At the same time the open unemployment rate increased by 3,7 percentage points in two years. Notice that in our NKPC estimation, positive movements of output growth have a positive effect on inflation. However, output also affect inflation by its effect on equation (3.2) in which interest rates is in equilibrium with inflation rate, output and money growth. Thus, if output increases, the interest rate has to decrease or inflation has to increase in order to return to equilibrium.

The overall effect on nominal interest rates and output are shown in Figure 2. Notice that, as expected, nominal interest rate would have increased compared with its historical growth. Inflation would have decreased as the relative effect by interest rates is more important than the output movements in the short run.

[INSERT FIGURE 2]

Now, we turn to the second question about the effect of the evolution of the American nominal interest rates after 2001:Q3.

We recall the unexpected monetary shock as a result of september 11th where the Federal Reserve responded with a drastic cut in interest rates.

Now, we perform the simulation with the interest rate path shown Figure 3. Now, nominal interest rate in the US affects Chilean inflation through its effect in the long run equilibrium in the external market given by expression (3.3). Notice that after a positive shock in i_t^* , i_t has to increase or π_t has to increase (or both) in order to return to the equilibrium in the foreign market.

[INSERT FIGURE 3]

Results of the simulation, shown in Figure 3, indicate that the effect of higher interest rates in the US is both a higher interest rate in Chile and a lower inflation rate.

7. Concluding Remarks.

In this paper we propose a new empirical approach to estimate a New Keynesian Phillips Curve (NKPC that jointly incorporates demand pressures in different markets. This procedure also allows to analyse inflation dynamics in the short and long run. Methodologically we apply a two step procedure. In the first step, potential cointegration relationships are separately analyzed in three different vector equilibrium models. Inflation is explained by (1) the effect of monetary and financial variables, (2) information on international markets, and (3) production cost. We apply the model to Chilena data. It has been found that there is a cointegration relationship in the monetary market that could be interpreted as a Taylor rule. The cointegration relation in the foreign market equalizes the real interest rate in the US with the Chilean one minus the pesos/dollar exchange rate. In the labour market we found two cointegration equations. One relating productivity to salary and inflation, and the other relating price inflation to productivity growth. In the second step, we have incorporated the

information obtained in the first step about the equilibrium relationships in different markets, to estimate the structural parameters of the NKPC. It has been found that inflation reacts to shocks in different markets, but that equilibrium in the labour market and output movements are the most important explanatory variables. Our approach can be considered a general case that nests other specifications in the literature, such as a traditional Phillips curve that only includes demand pressures coming from the output gap and the model proposed by Fanelli. Based on econometric tests, we can reject these specifications in favour of our model.

Given that we include information about different markets in one single equation, the estimated model has been used to estimate the effect on inflation of different shocks in output and foreign interest rates. It has been found that Chilean interest rates react to the different shocks to keep inflation under control.

Future lines of research are suggested by this work. First, given that our analysis suggests that different variables, representative of many theories, matter empirically an interesting exercise is to study the influence of different markets to forecast Chilean inflation. In this context, the analysis for the UK inflation proposed by Hendry (2001) is an interesting contribution to follow in future research on the Chilean inflation. Our second suggestion relates to extend our procedure in order to estimate a Complete New Keynesian model instead of just a NKPC. The estimation of New Keynesian models has been previously proposed by Rotemberg and Woodford (1999), Christiano et al. (2001) and Boivin and Giannoni (2003) among others. An interesting contribution would be to extend the methodology in this paper by including inertia forces coming from cointegration relationships coming from different markets.

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Appendix
Source of the series

The paper uses series from the first quarter in 1987 to the second quarter of 2006. The sources of the basic series are:

Real GDP: National Accounts, Chilean Central Bank.

Employment: National Employment Survey, National Statistics Institute, Chile.

Nominal Wages: Wage Index, National Statistics Institute, Chile.

Consumer Price Index: Consumer Price Survey, National Statistics Institute, Chile.

Unemployment Rate: National Employment Survey, National Statistics Institute, Chile.

Short Run Nominal Interest Rate: Average bank borrowing rate from 30 to 89 days, Chilean Central Bank.

M2 Money Definition: Chilean Central Bank.

Nominal Exchange Rate (Pesos/US dollar): Chilean Central Bank.

U.S Nominal Fed Rates: Federal Funds Monthly Effective Rate, Federal Reserve of the United States.

U.S. Consumer Price Index: United States Department of Labor, Bureau of Labor Statistics.

Monthly series were averaged to quartely frequency. Nominal wages and M2 were deflated by the consumer price index to obtain series in real terms. Average labor productivity was obtained as the ratio between employment and real GDP.

